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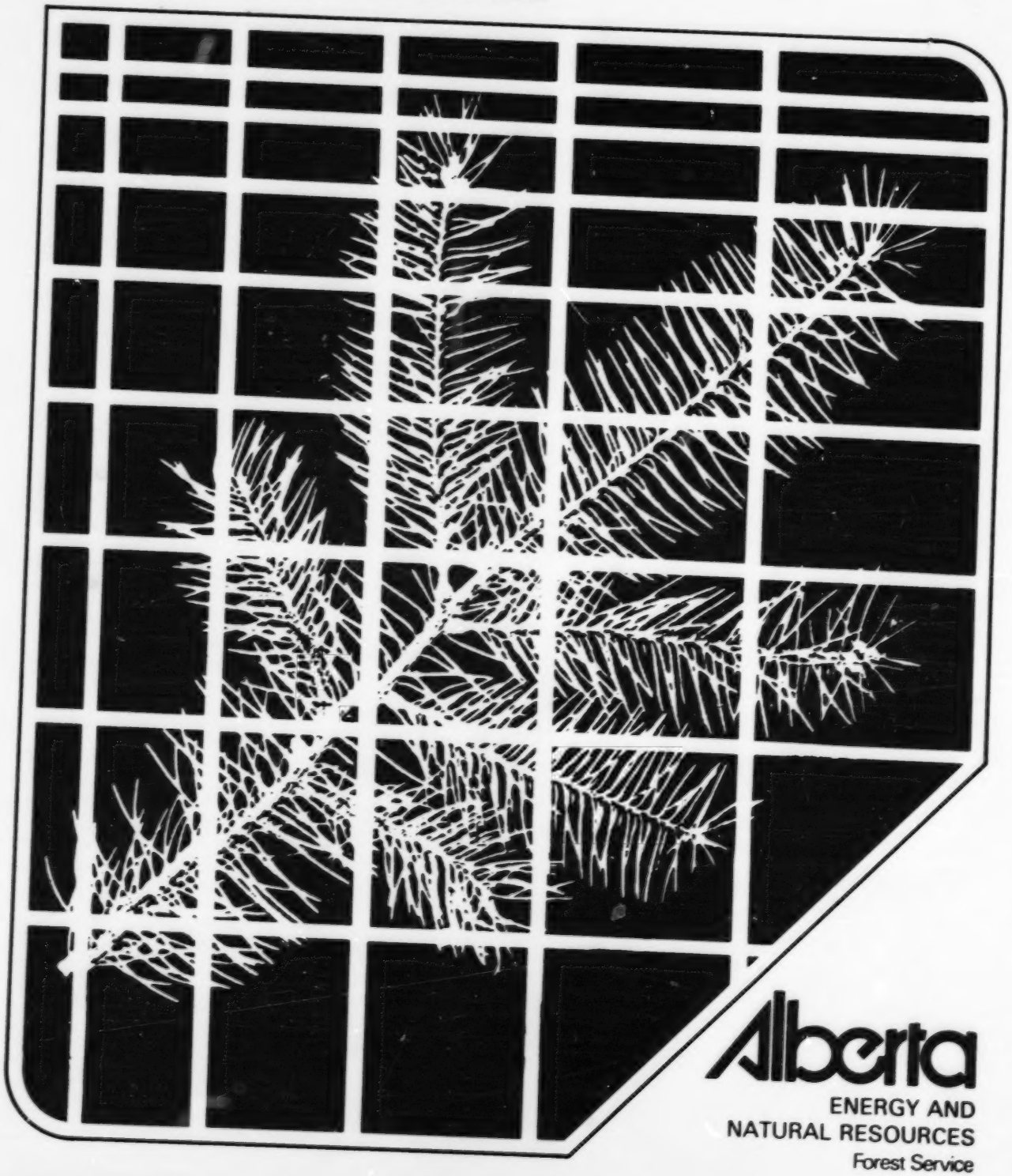
Lodgepole Pine and White Spruce

Growth and Survival After Herbicide and Fertilizer Treatments On Grassy Clear-Cut Forest Land



Alberta

ENERGY AND
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LODGEPOLE PINE AND WHITE SPRUCE GROWTH AND SURVIVAL AFTER HERBICIDE AND FERTILIZER TREATMENTS ON GRASSY CLEAR-CUT FOREST LAND

D.G. Blackmore

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Publications Section
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T5K 2C9
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ABSTRACT

One 9 g, 22-8-2 fertilizer tablet per lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm) and white spruce (Picea glauca (Moench) Voss) seedling resulted in increased height compared to unfertilized pine four years after planting, and unfertilized spruce five years after planting on clear-cut forest land north of Edson, Alberta. The greatest fertilizer-induced increases in height were observed for pine and spruce planted in scalps.

Pine and spruce planted in scalps (fertilized or unfertilized) displayed only marginal increases in height when compared to pine and spruce planted in the controls (fertilized and unfertilized).

Not less than 34 percent greater height growth was achieved by pine planted in strips sprayed with 4.5 ai/ha of glyphosate compared with the controls. Spruce did not benefit by the same glyphosate treatment.

Pine and spruce planted in plots treated with 7.8 and 15.7 kg ai/ha of the soil-active herbicide karbutilate suffered unacceptably low survival rates. Survival and condition of pine and spruce planted in 15.7 and 31.4 kg ai/ha of simazine were comparable to pine and spruce in the scalp and control treatments.

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1. INTRODUCTION

The experiments reported in this paper were established in 1976 and 1977 as a part of a Master's degree thesis completed in 1978 (Blackmore, 1978). Results of the more significant glyphosate (n (phosphononethyl) glycine) experiments were reported by Blackmore and Corns (1979). It was felt that significant benefit, involving later conifer response to the treatments, could be derived by current measurements and observations at the experimental plots still in existence. Permission to undertake the field work and report on the results was obtained through the Research Branch and the Forest Land Use Branch (in which the author is currently employed) of the Alberta Forest Service.

A brief summary of the materials and methods is provided for the benefit of the reader. The publications mentioned above must be referred to if more detail is required. Data is presented in a manner similar to the above publications to facilitate direct comparison if desired by the reader. The experiment code numbers used on field stakes at the Edson site are presented in this report in the event that in-the-field reference is necessary.

2. SUMMARY OF MATERIALS AND METHODS

Numerous experimental plots were established at five sites (four in forest clear-cuts in western Alberta from Edson to Grande Prairie and one near Edmonton) during the Master's thesis work. Three locations were eliminated from further study, as conifers from two sites were harvested for weight measurements and the third site originally involved a glyphosate rate trial with no conifer implants. Due to time limitations, only one of the two existing sites was selected for further study. This site was described by Blackmore and Corns (1979) as follows.

> The experimental site was located in the foothills of Alberta, 41 km N.W. of Edson (SW 33-56-18-W5) adjacent to mature lodgepole pine forest on land clearcut in 1967 and drag scarified in 1970. The soil, classified in Luvisolic order had developed on cobbly morainal deposits. The Alberta Department of Agriculture, Soil and Feed Testing Laboratory provided the following data for analysis representing the upper 15 cm of mineral soil: Available nutrients, kg/million kg soil-N:1 (low), P:18 (medium), K:103 (medium), pH:4.9, conductivity (mmhos):0.1, organic matter:low.
>
> May-August precipitation was about 430 mm during the experiment. Records indicate that showers are frequent during the summer months in that foothills region.
>
> The site had considerable variation in ground cover including deadfall, heavy grass usually on 8 to 15 cm of organic matter, alder (Alnus sp.) clumps, and patches of scattered forbs. Marsh reed grass was the dominant plant species. Fireweed (Epilobium angustifolium L.) was conspicuous.

The following is a brief summary of the materials and methods relating to the experiments reported in this paper. The reader is referred to the above-mentioned publications for a full, detailed description.

2.1 Glyphosate Experiments

2.1.1 Experiment 76-R-1-Pine

i Date of spraying: June 15, 1976

ii Application: 4.5 kg ai/ha in 325 L/ha of spray mixture

iii Date of planting: June 16, 1976

iv Number of implants per treatment: 50

v Treatments

1) Control

2) Scalp

3) 28 cm diameter treated spot (not measured)

4) 56 cm diameter treated spot (not measured)

5) 1.2 m x 25.3 m treated strip

6)-10) Treatments 1 to 5 were repeated with the addition of one 9 g 22-8-2 slow-release fertilizer tablet inserted at planting time within 2 cm of each seedling plug.

vi Replicates: 5 (Due to seedling mortality, only 4 replicates are considered in this experiment.)

2.1.2 Experiment 76-R-1-Spruce

This experiment is identical to 76-R-1 pine.

2.1.3 Experiment 76-R-5

i Date of spraying: August 21, 1976

ii Application rate: 4.5 kg ai/ha in 325 L/ha of spray mixture

iii Date of planting: August 22, 1976

iv Number of pine implants per treatment: 50

v Treatments:

1) Control

2) Scalp

3) 1.2 m x 25.3 m treated strip

vi Replicates: 3

2.1.4 Experiment 76-R-6

i Date of spraying: August 1, 1976

ii Application rate: 4.5 kg ai/ha in 325 L/ha of spray mixture

iii Date of planting: May 10, 1977

iv Number of pine implants per treatment: 20

v Treatments

1) Control

2) 1.2 m x 12.6 m treated strip

vi Replicates: 3

2.2 Soil Experiments

2.2.1 Experiment 76-R-4

i Date of treatment: July 6, 1976

ii Date of planting: July 6, 1976

iii Treatments (Each planting spot was covered with a 28 cm diameter paper plate before treatment.)

1) Control

2) Scalp

3) Karbutilate 4% granular at 7.8 kg ai/ha

4) Karbutilate 4% granular at 15.7 kg ai/ha

5) Simazine 4% granular at 15.7 kg ai/ha

6) Simazine 4% granular at 31.4 kg ai/ha

All plots were 1.2 m x 12.2 m

iv Number of implants: 17 pine and 17 spruce in the same plot

v Replicates: 3

2.3 Measurements and Observations

Measurements and observations were accomplished on experiment 76-R-1-pine on September 17, 1980 and on all other experiments on September 10, 1981.

2.3.1 Conifer Height Measurement

The pine and spruce were measured from the crown to the tip of the terminal bud. If the terminal bud was removed by browsing animals, the conifer was not included when determining the mean. Mean height data presented in this paper are based on surviving conifers.

2.3.2 Conifer Condition Rating

0 - Healthy

1 - Damaged

1T- Terminal damaged by browsing animals

2 - Dead

2.3.3 Conifer Survival Count

A count was made of all surviving pine and spruce in each plot.

2.3.4 Weed Control Rating

0 - 0-25% control

1 - 26-50% control

2 - 51-75% control

3 - 76-99% control

4 - 100% control

The weed-control rating was based on an estimate of cover compared to the untreated control plot.

3. RESULTS

3.1 Glyphosate Experiments

3.1.1 Pine Planted One Day After Treatment (Experiment 76-R-1-pine)

Survival and Condition

Four years after planting, the survival rate of lodgepole pine in all treatments was good. Survival rates were from 84 to 96 percent (Table 1).

The terminal and upper branches of more than one half of the pine in all treatments, except the glyphosate treatments, had been browsed. Pine in the glyphosate treatments appeared to be less severely browsed than all other treatments. The overall health of pine in all plots was excellent.

Height Growth

The addition of fertilizer appeared to increase the height of pine in all treatments. Pine in the fertilized scalp treatment displayed considerably greater height compared to pine in the unfertilized scalps (Table 1).

Scalping increased the height of pine by 22 percent compared to the control. When fertilizer was added to pine in the scalp treatment, height increased by 45.7 percent compared to the unfertilized control. Pine planted in the unfertilized glyphosate-sprayed strips displayed considerably greater height than pine in the unfertilized control and scalp (84.8 and 62.7 percent greater, respectively). The addition of fertilizer to pine in the sprayed strips also resulted in considerably greater height compared to the fertilized control and scalp (71.7 and 54.3 percent greater, respectively).

Table 1

SURVIVAL AND GROWTH OF LODGEPOLE PINE
ON SEPTEMBER 17, 1980 -- FOUR YEARS
AFTER TREATMENT AND PLANTING
(EXPERIMENT 76-R-1-PINE)

Treatments	Survival Rate %	Mean Height***	#Pl Assigned per Rating**			
			0	1	1T	2
Control	86	100%* (52.5cm)	8	0	35	7
Control & fertilizer	86	128.3	13	0	30	7
Scalp	84	122.1	14	0	28	8
Scalp & fertilizer	86	145.7	15	0	28	7
Glyphosate 4.5 kg ai/ha Strip	94	184.8	31	0	16	3
Strip & fertilizer	96	200.0	37	0	11	2

* Mean heights are expressed as percentages, with 100% representing the control.

** Condition Rating:

0 - Healthy

1 - Damaged

1T- Terminal Damage

2 - Dead

*** The mean heights are based on the heights of 8 pine with undamaged terminals, randomly selected from each treatment.

3.1.2 Spruce Planted One Day After Glyphosate Treatment (Experiment 76-R-1-spruce)

Survival and Condition

Five years after planting, the survival rate of white spruce in all treatments was good. The range was from 80 to 92 percent with the higher survival in the glyphosate-sprayed plots (Table 2). Fertilizer did not appear to affect the survival rate.

Approximately 15 percent of the spruce had leader damage as a result of browsing animals.

Height Growth

Similar to the case of pine, the addition of fertilizer appeared to increase the height of spruce in all treatments (but not significantly) except for spruce in the glyphosate-sprayed strips. Apparently as a result of fertilizer, the heights of spruce in the control and scalp plots were 12.2, and 18.8 percent greater, respectively, compared to the unfertilized plots (Table 2).

Planting spruce into scalps or glyphosate-sprayed strips did not result in significantly greater tree height after five years compared to spruce in the control; however, the means of spruce in all treatments ranged from 3.6 to 21.5 percent greater than the mean height of spruce in the unfertilized control. (Table 2).

3.1.3 Pine Planted One Day After Mid-Summer Treatment (Experiment 76-R-5)

Survival and Condition

Survival rates of lodgepole pine in the control and scalp treatments were good — 79 and 87 percent, respectively (Table 3). The

Table 2

SURVIVAL, GROWTH, AND CONDITION OF WHITE SPRUCE
ON SEPTEMBER 10, 1981 -- FIVE YEARS
AFTER TREATMENT AND PLANTING
(EXPERIMENT 76-R-1-SPRUCE)

Treatments	Survival Rate %	Mean Height*	#Sw Assigned per Rating**			
			0	1	1T	2
Control	82	100% (27.4cm) a***	36	0	7	7
Control & fertilizer	80	112.4 a	34	0	6	10
Scalp	82	103.6 a	38	1	2	9
Scalp & fertilizer	88	121.5 a	30	5	9	6
Glyphosate 4.5 kg ai/ha Strip	92	106.2 a	30	0	16	4
Strip & fertilizer	92	105.5 a	38	0	8	4

* Mean heights are expressed as percentages, with 100% representing the control.

** Condition Rating:

0 - Healthy

1 - Damaged

1T- Terminal Damage

2 - Dead

*** Percentages followed by the same letter are not significantly different at the 5% level using Analysis of Variance followed by Least Significant Difference for pairwise comparisons.

survival rate in the glyphosate-treated strip was 55 percent. The majority of the mortality in the glyphosate strip occurred immediately (probably within one week) after spraying in 1976. Reasons for this glyphosate-caused mortality are explored by Blackmore (1978). Glyphosate appeared to remain soil-active for a few days after application.

In the control and scalp treatments, approximately one half of the existing pine were damaged by browsing animals. In the glyphosate-treated strip, approximately one third of the pine were similarly damaged. Other than browsing damage, the pine in all plots were healthy.

Height Growth

The pine planted in the scalps did not attain a height greater than pine planted in the control. The pine that survived the glyphosate treatment had attained greater than 30 percent more mean height than pine in the control and scalp-treatment groups (Table 3).

3.1.4 Pine Planted 10 Months After Mid-Summer Treatment (Experiment 76-R-6)

Survival and Condition

The survival rate of pine in the sprayed plots was 93 percent, while the survival rate in the control plots was 72 percent (Table 4). The greater survival of pine in the sprayed plot was not significant at the five percent level; however, further analysis showed pine survival to be significantly greater at the 10 percent level in the sprayed plots.

The majority of the pine in both the control and sprayed strips had terminal or upper-branch damage due to browsing animals. Other than the browsed terminals and branches, the majority of pine appeared to be healthy and growing vigorously.

Table 3

SURVIVAL, GROWTH AND CONDITION OF LODGEPOLE PINE
ON SEPTEMBER 10, 1981 -- FIVE YEARS
AFTER TREATMENTS AND PLANTING
(EXPERIMENT 76-R-5).

Treatments	Survival Rate %	Mean Height*	#Sw Assigned per Rating**			
			0	1	1T	2
Control	79	100%*** (50.8cm)	65	0	53	2
Scalp	87	104.7 a	63	1	66	20
Glyphosate 4.5 kg ai/ha	55	134.8 a	62	1	20	67

* Mean heights are expressed as percentages, with 100% representing the control.

** Condition Ratings:

0 - Healthy

1 - Damaged

1T- Terminal Damage

2 - Dead

*** Percentages followed by the same letter are not significantly different at the 5% level using Analysis of Variance followed by Least Significant Difference for pairwise comparisons.

Table 4

SURVIVAL, AND CONDITION OF LODGEPOLE PINE
ON SEPTEMBER 10, 1981 -- FIVE YEARS
AFTER TREATMENT AND FOUR YEARS
AFTER PLANTING
(EXPERIMENT 76-R-6)

Treatments	Survival Rate %	#Sw Assigned per Rating*			
		0	1	1T	2
Control	72 a**	3	0	40	17
Glyphosate (4.5 kg ai/ha)	93 a (b***)	3	0	53	4

* Control Ratings:
0 - Healthy
1 - Damaged
1T- Terminal Damage
2 - Dead

** Percentages followed by the same letter are not significantly different at the 5% level using Analysis of Variance followed by Least Significant Difference for pairwise comparisons.

*** A significant difference is detected between treatments at the 10% level.

Height Growth

Only three pine implants in each treatment did not have browsing damage or did not suffer mortality; therefore, height-growth comparisons are not presented.

3.2 Soil Experiments

3.2.1 Pine and Spruce Planted the Same Day as Soil-Active Herbicide Treatment

Survival and Condition

Pine

The survival of pine in the karbutilate-treated plots was poor. Survival rate in the control plots was 72.6 percent, whereas survival in the 15.7 and 7.8 kg ai/ha plots was 23.6 and 51.0 percent, respectively (Table 5). Surviving pine lacked vigor and were generally stunted.

Survival of pine in all simazine-treated plots was similar to survival of pine in the scalp treatment (ranging from 60.8 to 66.6 percent). Pine were growing vigorously in all simazine-treated plots.

Spruce

Spruce survival was poor in the karbutilate-treated plots -- 8 and 53 percent in the 15.7 and 7.8 kg ai/ha plots, respectively, compared to 82 percent survival of spruce in both the control and scalp treatments (Table 5). Condition of spruce in the 7.8 kg ai/ha plot was fair while the few surviving spruce in the 15.7 kg ai/ha plots were stunted and in poor condition.

Both condition and survival of spruce were better than pine in all simazine-treated plots. The survival rate in both the 15.7 and 31.4 kg ai/ha plots was 78 percent compared to the survival rate in the control and scalp treatments, which was 82 percent.

Weed Control Rating

Re-invasion of vegetation into the scalps was almost 100 percent after five years. The karbutilate treatments of 7.8 and 15.7 kg ai/ha displayed a cover reduction of approximately 8 and 15 percent, respectively. Simazine at 15.7 kg ai/ha showed only slight cover reduction while simazine at 31.4 kg ai/ha resulted in a vegetation cover reduction of approximately 35 percent, five years after treatment.

Table 5

SURVIVAL OF LODGEPOLE PINE AND WHITE SPRUCE
AND PLOT WEED CONTROL RATING*
ON SEPTEMBER 10, 1981 -- FIVE YEARS
AFTER PLANTING AND TREATMENT
WITH SOIL-ACTIVE HERBICIDES
(EXPERIMENT 76-R-4)

Treatments	Survival Rate %		Weed Control
	Pine	Spruce	Rating*
Control	72.6	82	0
Scalp	64.7	82	0+
Karbutilate			
7.8 kg ai/ha	51.0	53	0.7
15.7 kg ai/ha	23.6	8	1.3
Simazine			
15.7 kg ai/ha	66.6	78	0+
31.4 kg ai/ha	60.8	78	2.3

* Plot Weed Control Rating:

0 - No Cover Reduction
1 - 1-25% Cover Reduction
2 - 26-50% Cover Reduction
3 - 51-75% Cover Reduction
4 - 76-100% Cover Reduction

4. DISCUSSION AND CONCLUSIONS

4.1 Glyphosate Treatments

4.1.1 Pine

Fertilizer treatment assisted the growth rate of pine in all treatments. The most benefit was derived by pine planted in the scalps. This suggests that fertilizer may be more effective when implanted in mineral soil in scalps. Many fertilizer tablets in the control and sprayed strips were implanted into peat duff beside the seedling root plugs.

The glyphosate-treated strips provided a competition-reduced site resulting in major growth benefits for pine. From 34 to 71 percent more height growth was obtained by reducing competition with glyphosate at this experiment site.

The survival of pine in the glyphosate-sprayed strips in one experiment (76-R-5) was low (55 percent) compared to pine survival in the control and scalps (79 and 87, respectively). The mortality appeared to occur within the first week after treatment and planting (Blackmore 1978). This mortality problem can be eliminated by planting pine one week or later after glyphosate treatment.

Pine planted in scalp treatments did not achieve significantly greater growth than pine in the controls; therefore, in this experiment, scalping appeared to provide little benefit to the pine.

Pine in all experiments and treatments suffered considerable damage as a result of browsing by animals; however, most pine remained healthy and vigorous and continued to replace lost leaders.

4.1.2 Spruce

The addition of fertilizer tablets appeared to assist spruce in achieving greater height, but not significantly. Similar to its effect on pine, fertilizer provided greatest assistance for spruce planted in the scalp treatment.

The use of glyphosate to prepare competition-reduced planting sites did not benefit spruce in either fertilized or unfertilized plots. Spruce seedling are adapted to growth under the shade provided by an overstory; therefore, removal of the shading effects of grass and forb cover may have negated the positive effect of reduced competition.

4.2 Soil Treatments

Treatment with karbutilate resulted in unacceptably low survival rates and condition of both pine and spruce. It appears that this herbicide may not be useful in studies of this type or in operational reforestation.

Survival and condition of pine and spruce in the simazine plots were comparable to pine and spruce in the control and scalp treatments. No growth measurements were taken in this experiment; therefore, no statement of benefit or otherwise can be made. This herbicide should be considered for further studies of this nature.

The highest rate of application of simazine had provided 35 percent cover reduction after five years. Loss of cover for this length of time could result in detrimental effects such as erosion and loss of wildlife habitat. The effects of smaller amounts of this herbicide should be investigated further in reforestation studies.

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